



Geoheritage of a Brazilian Semi-Arid Environment: the Seridó Aspiring UNESCO Geopark

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Abstract

Since the end of 2019, two new Brazilian areas are candidates to join UGG/GGN; one of them is Seridó Aspiring UNESCO Geopark, located in the country's Northeast, state of Rio Grande do Norte. It is named after a native Brazilian word, of tapuia tradition — *ceri-toh* — which means “little or no foliage; little shade,” something that well defines its landscape, typical of the Caatinga Biome, which is only found in Brazil, and semiarid climate. The local geology comprises eight lithological clusters dating from the Paleoproterozoic to recent. It is a highly diverse territory, whose inventory of geological heritage comprises 21 geosites, with different types of interests, such as mineralogical, petrological (plutonic and volcanic), hydrological, geomorphological, and paleontological, among others, of regional to international relevance. They are integrated with the communities of the region through culture, economy, tourism, and science. Many are recognized by population as a heritage of Seridó. This paper describes all the geosites of the proposed geopark, also analyzing socio-cultural and environmental factors, and hazards related to geological heritage and its surroundings, such as cavities and archeological sites, Caatinga biome conservation, water use, *Quilombola* and settlement communities, urban proximity, risks in slopes, and especially with regard to the relationship of mining activities in the region, which since the 1940s has boosted the local and regional economy, with the exploitation of scheelite in the Brejuí Mine, the largest mine of its kind in South America, currently one of the geopark's geosites that has a high scientific value, notably of international relevance.

Keywords Brazil · Geoheritage · Inventory · Semiarid environment · Seridó Geopark

Introduction

Brazil is the largest country in South America and the fifth-largest in the world, in territorial extension. Despite its remarkable natural diversity, whose biodiversity has

international prominence, the country currently has only one UNESCO global geopark, the Araripe Geopark, in the state of Ceará Brazilian Northeast, a member of the International Geoscience and Geoparks Program (IGGP) since 2015, which certifies the territory in UNESCO Global Geopark (UGG), and of the Global Geoparks Network (GGN) since 2006. Therefore, 14 years after the first global geopark in Brazil, no other territory has been integrated into the UGG/GGN. This fact clearly expresses the need for more intense development of sustainable territorial projects that aim to implement geoparks and strengthen the dissemination of the Brazilian geological heritage. This reality is also observed in other Latin American countries (Sánchez-Cortez and Simbaña-Tasiguano 2018; Rosado-González et al. 2020), region which has only eight geoparks.

Several challenges are still faced so that the country can effectively have new territories with the designation of global geopark; among these, Rocha et al. (2017) point out the lack of specific legislation on geoheritage, difficulties in heritage education, strategic planning, and dialog

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between public and private entities in the territories. However, some initiatives have been successful in recent years in establishing concrete projects, including the submission of applications to UNESCO. In late 2019, in November, Brazil submitted two applications to UGG/GGN that became, in early 2020, Aspiring Geoparks (more details at <http://www.unesco.org/new/en/natural-sciences/environment/earth-sciences/unesco-global-geoparks/new-applications/>), and in June 2020, two other projects submitted their letters of intent.

One of the current Brazilian candidacies for global geopark is from Seridó Aspiring Geopark, northeast, which since 2010 has been developed with the territory's communities, as well as in the strengthening of scientific knowledge about the region. Still as a project, the geopark has shown strength as a tourist attraction, in education projects and through environmentally sustainable development based on its geological heritage (Medeiros et al. 2017; Meira et al. 2019).

In this article, we present the Seridó Aspiring Geopark, through its geology and the inventory of its geoheritage, with 21 geosites. We also present considerations about geological hazards, socio-environmental factors, and how the geoheritage of this semi-arid region is closely connected with its biological and cultural aspects.

Study Area

The Seridó Aspiring Geopark is located in the state of Rio Grande do Norte, far northeast of Brazil (Fig. 1). The territory is 180 km distant from the state capital, Natal, and comprises a total area of 2802 km², with an estimated population of more than 110,000 inhabitants. This territory is encompassed by the Caatinga Biome, which occurs only in Brazil and is marked by intense periods of drought, which denotes xerophilous vegetation, adapted to this climatic reality.

Geologically, the territory is inserted in the Borborema Province, one of the 10 structural provinces in Brazil, elucidated by Almeida et al. (1981) as a regional folding system, developed over the Brasiliano Cycle in Ediacaran, characterized by high-grade metamorphism, intense tectonics, and expressive granitogenesis.

Locally, seven main geological clusters are found (Fig. 2), from the base to the top: Caicó Complex, Seridó Group, three intrusive suites, Rio Ceará-Mirim Volcanism, Macau Volcanism, and Serra dos Martins Formation.

Caicó Complex (Paleoproterozoic/Riacian)

The Caicó Complex was first described by Meunier (1964) as a unit with intercalations between quartzites and gneisses. Jardim de Sá (1994) defines the complex as the basement of the Seridó Belt, composed of gneissic-migmatitic rocks. Souza et al. (2007) point out an analogy of the Caicó



Fig. 1 Rio Grande do Norte State and Seridó Aspiring Geopark localization

Complex metaplutonic rocks placement with the Andes continental margin granitoids of crustal accretion.

This unit has a great variety of rocks, such as paragneisses, amphibolites, ferriferous quartzites, banded iron formations, banded gneisses, and migmatites and also, the tonalitic-granodioritic-granitic orthogneisses, granitic leuco-orthogneisses with lens-shaped amphibolitic rocks and augen gneisses (Nascimento and Ferreira 2012). Medeiros et al. (2012) dated orthogneisses correlated to the ones outcropping in the area with an age of 2.2 Ga, from the Riacian period, and identified these as acid rocks with signatures between alkaline and calc-alkaline series.

Seridó Group (Neoproterozoic/Ediacaran)

The Seridó Group constitutes a belt of folded supracrustal rocks whose deformation is associated with the Brasiliano Cycle. There is a major NNE-oriented trend affecting this unit. Currently, the unit stratigraphic sequence considers the Jucurutu Formation at the base, overlapped by the Equador Formation and the Seridó Formation at the top. Therefore, it is the main geological unit found in the region, represented by metamorphic rocks, such as paragneisses, quartzites, metaconglomerates, micaschists, marbles, and calc-silicate rocks with rocks from Seridó Group having evidence of greenschist and amphibolite facies (Angelim et al. 2006).

From the analysis of detrital zircons, Van Schmus et al. (2003) say that the time window for the deposition of siliciclastic sediments from the Seridó Group was between 650 and 610 Ma, representing a sediment stacking of multiple

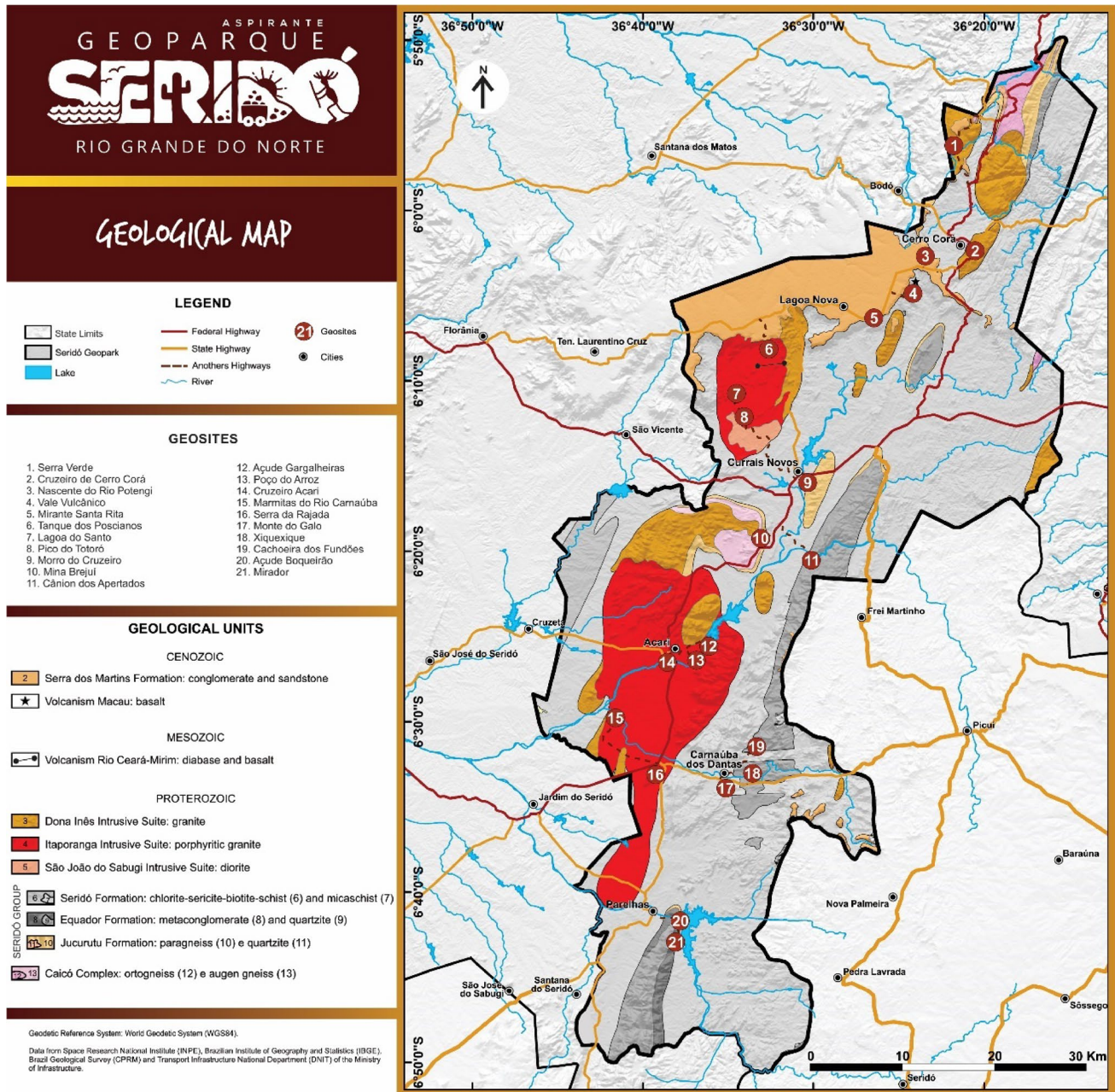


Fig. 2 Geological map for the study area, with geosites' localization

kilometers during the Neoproterozoic, a little before of the Brasiliano orogeny deformation that affected it.

Jucurutu Formation

The base of Seridó Group is composed essentially of paragneisses with a variable composition of biotite, epidote, and amphibole and is also composed of calc-silicate rocks, skarns, micaschists, quartzites, banded iron formations, basic to intermediate metavolcanics, and basal metaconglomerates with possible layers of metacherts (Angelim

et al. 2006). The protosediment deposition occurred in a shallow to continental marine environment (Jardim de Sá 1994). Important scheelite (CaWO_4) occurrences are found in this unit, which is the main ore exploration found in the region of the Seridó Aspiring Geopark.

Equador Formation

It consists of mainly muscovite quartzites, presenting arco-sean facies and intercalations with metaconglomerates,

deposited through a shallow marine sedimentation (Angelim et al. 2006).

Seridó Formation

It is represented by aluminous or feldspathic micaschists. At the base of this unit, there is an occurrence of marbles, calc-silicate rocks, paragneisses, metavolcanics, quartzites, and metaconglomerates intercalations. The deposition was interpreted by Jardim de Sá (1994) as typically associated with a distal platform or slope environment. The metamorphism has reached intermediate to high grade, resulting in very deformed rocks, presenting staurolite, andalusite, cordierite, and sillimanite associations (Angelim et al. 2006).

Intrusive Igneous Suites (Neoproterozoic–Paleozoic/Ediacaran–Cambrian)

Between 600 and 550 Ma, the region was intruded by multiple igneous bodies, typically granitoids, recognized as three main suites: Dona Inês, Itaporanga, and São João do Sabugi. Major events date back to the Ediacaran, in a pre to post Brasiliano orogeny magmatism.

Dona Inês

This suite occurs with dikes and sills emplacement. It consists of monzogranites and tonalites, fine to medium-grained, equigranular, presenting, sometimes, micro porphyritic variations and facies with coarse-grained textures to pegmatitic (Angelim et al. 2006). Archanjo et al. (2013) presented an age of 572 Ma obtained through SHRIMP zircon analysis, associated with fine-grained facies, from the Acari pluton. While Holanda et al. (2017) obtained an age of 527 Ma to the Cerro Corá pluton and Souza et al. (2016) presented the age of 532 Ma to the Macambira pluton, both associated with the Dona Inês suite.

Itaporanga

It consists of a group of igneous bodies with major occurrences in the territory, representing an important magmatic event during the Brasiliano Cycle. It is composed of monzogranites, with variations to quartz monzonites, sienogranites, or granodiorites. Its porphyritic texture is the main feature of these rocks in the region (Angelim et al. 2006). Archanjo et al. (2013) pointed to a crystallization age of 591 Ma, from U–Pb analysis of the Totoró pluton, and 577 Ma for the Acari pluton, both described as of the Itaporanga suite.

São João do Sabugi

It consists of basic to intermediate plutonic rocks, presenting gray to black color, fine to medium-grained. It is essentially composed of gabbros, gabbro-norites, diorites, quartz diorites, monzodiorites, monzonites, quartz monzonites, tonalites, and granodiorites (Angelim et al. 2006). In terms of geochronology, Archanjo et al. (2013) presented ages of 597 and 595 Ma to the Totoró pluton, associated with this plutonic suite.

Pegmatite Dikes

Another memorable igneous feature in the landscapes of the Seridó Aspiring Geopark is the pegmatite bodies found throughout the region, mainly placed in the Seridó Formation micaschists. It is classified into homogeneous, heterogeneous, and mixed. Mineralogically, it is composed of microcline, plagioclase, quartz, muscovite, and biotite megacrysts (Angelim et al. 2006).

Nascimento et al. (2015) point out that these pegmatites are dated between 515 and 510 Ma and are therefore Cambrian occurrences. Baumgartner et al. (2006) indicate that, due to age and absence of deformation in heterogeneous pegmatites, these are late to post-tectonic, representing the end of the Brasiliano Orogeny in the region, whose regime changed from compressive to extensive, allowing the rise of magmatic material through pre-existing NE-SW-directed structures that mark the preferred orientation of the pegmatitic bodies in the Seridó Aspiring Geopark.

The pegmatites of this region are also known as components of the Seridó Pegmatitic Province and have mineralizations of aquamarine, tourmaline, beryl, and columbite-tantalite, for example. Some bodies are known in the literature and have active exploration, as shown by the work of Santos et al. (2016).

Rio Ceará-Mirim Volcanism (Mesozoic/Cretaceous)

Established in the context of the Potiguar basin rift phase, consisting of basaltic dykes E-W oriented intruding the basement. It was dated to about 130 Ma and is best expressed in swarms on the southern rim of the basin (Angelim et al. 2006). In the Seridó Aspiring Geopark area, dykes of metric extensions can be found south of the Serra de Santana.

Macau Volcanism (Cenozoic/Paleogene)

A volcanism event registered in the state geological context was dated to 25 Ma (Silveira 2006) and extends for over 100 km at the central north part of the state. It is composed of alkaline rocks such as olivine basalts, basanites, ankaramites, and nephelinites, rare peridotite nodules, with fine to

aphanitic granulation, and may present vesicular texture. It occurs in the form of lava flows, dikes, plugs, and necks, the best-known example being the neck of Pico do Cabugi (Angelim et al. 2006). In the Seridó Aspiring Geopark area, Macau Basalt is found in the form of columnar disjunctions on the hillside of the Serra de Santana, between the municipalities of Cerro Corá and Lagoa Nova, dated 25 Ma (Silveira 2006).

Serra dos Martins Formation (Cenozoic/Neogene)

A unit composed of Cenozoic sedimentary rocks was found capping the mountains, forming flat to slightly undulating landform, with abrupt cliffs and irregular contours, with altitudes around 700 m (Angelim et al. 2006). It is composed of coarse-grained sandstones with incipient lamination deposited in a fluvial system (Menezes 1999). At the top, ferruginous cement and talus deposits of 1 to 2 m thick are usually found. In general, the Serra do Martins Formation does not exceed 50 m in thickness on the Serra plateaus and is considered for having no fossiliferous content. Its deposition age is attributed to the time window between the Upper Oligocene and the Lower Miocene and may have 20 Ma in the Serra de Santana region (Lima 2008).

Methodology

Geosites Description

The descriptions of the sites that make up the inventory of the Seridó Aspiring Geopark were made based on fieldworks carried out over the 9 years prior to the submission of the project for evaluation by UNESCO. In this paper, the 21 geosites are described in a simplified way, based on the observations made and published works that are specifically about the inventoried areas.

Analysis of Environmental and Social Vulnerability

To carry out the analysis and study on the conditions of environmental and social vulnerability in the territory and in the geosites, different cartographic data from databases of Brazilian government agencies were used, such as the National Center for Research and Conservation of Caves (CECAV) for the location data of cavities, karst and caves; National Register of Archeological Sites (CNSA) of the National Historical and Artistic Heritage Institute (IPHAN) for sites with archeological artifacts and records; area of conservation units at the Chico Mendes Institute for Biodiversity Conservation (ICMbio) and the caatinga conservation priorities of the Ministry of the Environment (MMA); and finally for land tenure issues and quilombola settlement,

vector data from the National Institute of Colonization and Agrarian Reform (INCRA).

The analyses were carried out by making proximity and overlapping relations of vector data in the geoprocessing software ArcMap 10.5. StreetView© and Google Earth Pro© were also used to verify relations of environmental, geological, and social risks. These risks in turn are linked to the state of conservation of vegetation on hillsides, buildings on hillsides and proximity to granite blocks, deterioration of natural elements of the landscape, use and occupation of soil in the territory. Additionally, the data and results obtained by Silva et al. (2019a) and Costa et al. (2019) on the threats to geodiversity in the Seridó Aspiring Geopark also supported the discussions regarding the anthropic impacts on geosites, the second work used spatial analyses between mining polygons of the National Mining Agency (ANM), geosites, and the geodiversity indexes of the territory.

The review of technical documents, bibliographies, resolutions, and environmental laws, in Brazilian municipal, state, and federal spheres, also made up the discussions proposed in this work in order to discuss direct and indirect actions for geoconservation.

Inventory

Geosites Description

01— Serra Verde

The predominant rock at the site is an equigranular medium to coarse granite, composed essentially of quartz, K-feldspar, plagioclase, and biotite. The diversity of geofoms can be highlighted in the geosite, such as Pedra do Caju (Cashew Stone), Pedra da Baleia (Whale Stone), Pedra do Nariz (Nose Stone), and Cabeça de Cachorro/Dinossauro (Dog/Dinosaur Head). There is also a tank, periodically filled with water, in which fossil remnants of Pleistocene fauna have been found, but systematic work still needs to be done to better describe these findings. You can still see rock paintings of ancient peoples who inhabited the region, these found in cave walls formed by cavities dissolved in granite.

02— Cruzeiro de Cerro Corá

It is one of the main local tourist spots, close to the reservoir that supplies the municipality of Cerro Corá. Geologically, it is composed of numerous blocks and slabs of medium to coarse granite, composed essentially of K-feldspar, quartz, and plagioclase. On the granite are positioned a cruise and it is a viewpoint to the city and the Serra de Santana.

03— Nascente do Rio Potengi

The Potengi River is one of the main tributaries of Rio Grande do Norte, covering 170 km from Seridó until it flows into the Atlantic Ocean, in the capital Natal. It is associated with the history of Rio Grande do Sul itself, since the former hereditary captaincy of Rio Grande, which gave rise to the state, was named by Portuguese colonizers after facing the river's mouth. In this geosite, there is a river's source, which occurs through coarse to very coarse sandstones and conglomerates (Fig. 3a).

04— Vale Vulcânico

Its main highlight is the occurrence of basalts with columnar disjunctions (Fig. 3b) from different dips, ranging from horizontal to inclined (70° SE). Vesicular texture and some

peridotite xenolites are perceived. The main minerals in volcanic rock are olivine, clinopyroxene, and plagioclase. The existence of blocks rolled along the slope forms an expressive deposit of talus in the geosite.

05— Mirante Santa Rita

Coarse to very coarse sandstones predominate, sometimes tending to conglomerates, from light brown to whitish in color. They have large cross-stratified stratifications or are sometimes massive, containing pebbles and clay granules.

06— Tanque dos Poscianos

The main lithology is a medium to porphyritic granite, composed essentially of K-feldspar, quartz, plagioclase, amphibole, and biotite. Dioritic enclaves and pegmatite dikes are

Fig. 3 Geosites from the Seridó Aspiring Geopark: **a** Nascente do Rio Potengi; **b** Vale Vulcânico; **c** Tanque dos Poscianos; **d** Morro do Cruzeiro; **e** Mina Brejuí; **f** Cânions dos Apertados; **g** Açude Gargalheiras; **h** Monte do Galo; **i** Mirador. Photos: **a**, **e**, **f**, and **g**, Getson Luís; **b** and **i**, Marcos Nascimento; **c** and **d**, Matheus Lisboa; **h**, Eugênio Oliveira



still observed, cutting through the main lithology. Through the action of weathering and erosion, several tanks were formed in granite, in which the accumulation of rainwater occurs. On the geosite, it is possible to have a panoramic view of part of the territory (Fig. 3c).

07— Lagoa do Santo

There are medium to coarse granite slabs and blocks, composed essentially of K-feldspar, plagioclase, quartz, biotite, amphibole, and opaque minerals. Several enclaves of dioritic rocks are found, as well as coarse granite. Pegmatite dykes in different directions and dimensions are also present. Fragile deformation structures are also observed, such as joints and faults, well marked by the displacement of the veins. Geoforms such as Pedra da Tartaruga (Turtle Stone) are observed, in addition to the attractive Pedra do Sino (Bell Stone), a granite block that, due to its position of stability with the underlying block, produces a chime sound when it is hit with another rock or metallic material. Rock paintings are also present in this geosite.

08— Pico do Totoró

Geologically, granites with porphyritic portions are found, composed of K-feldspar, quartz, plagioclase, biotite, amphibole, titanite, and opaque minerals. The Pedra do Navio (Ship Stone) and Pedra do Caju (Cashew Stone) geoforms stand out in the geosite. It is a recognized place in local culture, being mentioned in the official anthem of the city of Currais Novos, in addition to being an inspiration for various artistic expressions, such as paintings, poems, and songs.

09— Morro do Cruzeiro

The geosite can be seen from several points in the municipality of Currais Novos as it is in a higher position on the ground. It is a pegmatite body, with an approximate NS direction, composed essentially of K-feldspar, quartz, plagioclase, in addition to biotite, muscovite, and titanite, and which is embedded in a micaschist, rich in biotite and garnet, bent from the Seridó Formation. A cruise was placed on the pegmatite (Fig. 3d) and, therefore, the geosite has cultural significance for the local community, being the site of religious pilgrimages throughout the year. Due to its location, it also provides a panoramic view of the city. Currently, it is protected by municipal legislation as it is an important component of the region's natural landscape.

10— Mina Brejuí

This is composed of the main scheelite mine (CaWO_4) in South America. It is a classic example of the mineral

potential of this region of northeastern Brazil, in addition to highlighting the relationship between mining activity and the community in which it operates. Geologically, the mine complex is correlated with the Jucurutu Formation, presenting an alternation between paragneisses, marbles, and calc-silicate rocks. The paragneisses are constituted essentially of quartz, feldspar, and biotite; it is marking strong orientation, in addition to epidote, microcline, muscovite, opaque minerals, and tremolite/actinolite. The calc-silicate rocks have an epidote, titanite, quartz, plagioclase, apatite, hornblende, malachite, molybdenite, and tremolite/actinolite composition. Marble lenses are formed by calcite, with accessory minerals: opaque minerals, tremolite, and white mica. Micaschists from the Seridó Formation also occur in the region.

Since the establishment of mining in the 1940s, the city of Currais Novos showed great development, which enabled the municipality to install movie theaters and even the first cable TV operator in the North-Northeast. With the price decline of the commodity, there was a reduction in production and eventual closure throughout the 1990s, which resumed only at the end of the following decade. Despite this, a theme park was established by the company in 2000, encompassing the Mineral Museum, Memorial to the founder of the mine and visits to the disabled exploration galleries (Fig. 3e), which became the main attraction of this geosite, today the largest theme park in the state of Rio Grande do Norte.

11— Cânions dos Apertados

This geosite has as its fundamental characteristic the existence of canyons, formed by the Picuí river erosion, which cut and shaped the rocks of Serra da Timbaúba (Fig. 3f). The main lithology found is the quartzite of the Equador Formation, consisting essentially of quartz, but which still contains micas (muscovite and biotite), and some mafic minerals. The rock was generated by the metamorphism of sedimentary protoliths and preserves sedimentation structures and stratifications. The geosite presents, mainly, geomorphological attractions, associated with the process of erosion of the mountain by river erosion, which generated a unique environment, with the presence of potholes, and which demonstrates a high scenic quality. It is also possible to identify some geoforms, such as the Cabeça do Índio (Indian Heag), in addition to the existence of a small shelter under rock.

12— Açude Gargalheiras

The site is formed by several granites, essentially composed of K-feldspar, quartz, and plagioclase, in addition to micas (biotite and muscovite), apatite, zircon, amphibole, titanite, alanite, and opaque minerals. The relief of the mountains, cut by the Acauã River, forms the bottleneck that was used

for the dam to supply the region in what is the main reservoir of the Seridó region (Fig. 3g). Even today, there is a community that remains from the time of the construction of the dam, when a small village was built for workers.

13— Poço do Arroz

There are blocks of medium to coarse granite, composed essentially of K-feldspar, quartz, and plagioclase, in addition to biotite, amphibole, titanite, and opaque minerals. The elements that make up the geosite are the potholes formed by river erosion, whose strength of the weather was given by the movement of the Acauã River, facilitated by sets of fragile deformation structures. The existence of potholes was a facilitator for prehistoric people to use them to make records in the form of lithographs, which have become one of the geosite's main attractions. Another highlight of the place is its scenic beauty, formed by the erosive and tectonic processes in the region.

14— Cruzeiro de Acari

It consists of blocks of medium to coarse granites, essentially composed of centimetric K-feldspar crystals, quartz, and plagioclase, in addition to biotite, amphibole, titanite, and opaque minerals. Mafic enclaves of dioritic composition can be observed. The orientation of the crystals is evidence of a magmatic flow. In some blocks, it is possible to see a texture similar to rapakivi in the feldspar crystals.

15— Marmitas do Rio Carnaúba

It is formed by medium to coarse granites, composed of K-feldspar, quartz, and plagioclase, in addition to biotite, amphibole, titanite, and opaque minerals. Cutting the rock, there are several fine granite dikes, and these are composed of K-feldspar, quartz, opaque minerals, tourmaline, and beryl. Fragile structures of N-NE direction deformation, such as fractures and faults, are common in the geosite. The main highlights of the place are the potholes, of varying dimensions, reaching metric levels, in a set that extends 800 m along the riverbed. The formation of this feature by fluvial erosion was essential for the inscription on the rock of lithographs by ancient peoples, with different geometric shapes, similar to what was done at the Poço do Arroz Geosite.

16— Serra da Rajada

It stands out in the local relief as an imposing inselberg and can be seen from a distance, with a height of about 500 m. It is a granitic body, with NE-SW direction, formed essentially by quartz, feldspar, plagioclase, and biotite. The

geosite stands out for the huge walls inviting for adventure tourism practices, such as abseiling, climbing, mountaineering, trekking, among others, in addition to contemplating the landscape at its top.

17— Monte do Galo

Another highlight in the local relief, the geosite can be seen from a distance, with an average height of 150 m. It is a pegmatite body, with NE-SW direction, formed essentially by quartz, feldspar, plagioclase, biotite, muscovite, and tourmaline. On the body, since 1927, there has been a religious monument of Catholic tradition, dedicated to Our Lady of Victories, a place of pilgrimage and a viewpoint for the entire southern region of Seridó (Fig. 3h).

18— Xiquexique

The predominant lithology in the place is the quartzite of the Equador Formation (Seridó Group), composed essentially of quartz. There are also some muscovite, biotite, and opaque crystals. Structurally, the outcrop has fragile tectonic structures, but ductile structures such as recumbent folds are more evident. The main highlights are the rock paintings, Brazilian cultural heritage, drawn on the quartzite walls and which bring three main themes, hunting, dance, and sex, and which inspire the creation of geoproducts. The site currently has well-structured visitation conditions, with support equipment along the approximately 1 km path that leads to the geosite, which makes it possible to visit different audiences.

19— Cachoeira dos Fundões

Geologically, quartzites and pegmatites are found. The quartzites belong to the Equador Formation; they present fine to medium granulometry and are whitish to gray in color, tending to cream tones, with the shine of micaceous minerals and some dark mineral points. They are composed of quartz, muscovite, biotite, black tourmaline, and opaque minerals. They are presented in slabs and in the form of walls (canyons) approximately 70 m high in a canyon known as “Cachoeira dos Fundões,” “Poço dos Fundões,” or just “Fundões.” In the walls, the quartzite is cut by countless bodies of pegmatites filling fractures from different directions. Pegmatite occurs in the form of veins, dikes, sills, veins, and pockets. It is medium to coarse in texture, has a cream to pink color, and is made up of quartz, K-feldspar, plagioclase, biotite, muscovite, and tourmaline.

20— Açude Boqueirão

This geosite has a geodiversity composed of lithologies such as metaconglomerate and quartzite and has several

geomorphological highlights in its characteristics. It comprises the area surrounding the Boqueirão Dam. Metaconglomerates, comprised by the Equador Formation, are composed of pebbles of gneisses, schists, and quartzites in a matrix, of medium size, formed by plagioclase, quartz, microcline, biotite, chlorite, titanite, and opaque. Quartzites, from the same Formation, are composed of quartz, being accessories: muscovite, epidote, and opaque minerals. Pegmatite dikes are also found along the geosite. All the rocks in the region are subject to mineral extraction with several applications, with emphasis on ornamental exploration.

The existence of a positive relief is evident in the area, known as Serra das Queimadas, with N-S orientation. The action of fluvial erosion cut the mountain to form a gorge or mouth. The current form of the relief is interpreted, in the local culture, as the silhouette of a sleeping woman, known as Sleeping Princess, Parelhas city symbol.

21— Mirador

Carbonate metaconglomerates and quartzites of the Equador Formation occur. It is possible to observe, on site, the intense action of weather that produces rock dissolution. This process is also responsible for the shape of the site, known as Pedra da Boca (Mouth Stone), which was used as a shelter by prehistoric people, evidenced by mortuary

chambers and rock paintings found in the geosite (Fig. 3i). Currently, the site, which is also listed as a national cultural heritage, has a visitation structure similar to that of the Xiquexique Geosite, although in simpler conditions, which facilitates the observation of the rock paintings.

Geosites Through Geological Time

The Seridó Aspiring Geopark’s geosites reflect the territory’s geological history, being representatives of the main lithological groups of the region, which developed mainly along the Neoproterozoic and Cambrian, as in the case of the Seridó Group and intrusive igneous rocks. Afterwards, the occurrences recorded in the geosites are Paleogene and Neogene, especially those of basaltic spills dated to 25 Ma and of Cenozoic sedimentary rocks. Figure 4 shows the positioning of the 21 geosites over geological time, identifying at least 4 main geological periods.

Geodiversity, Urbanization, and Natural hazards Around Geosites

Seridó was based on the colonization of cattle from the coast to the countryside, which became known for the cattle cycle, which used the landscape of humid valleys and natural ponds

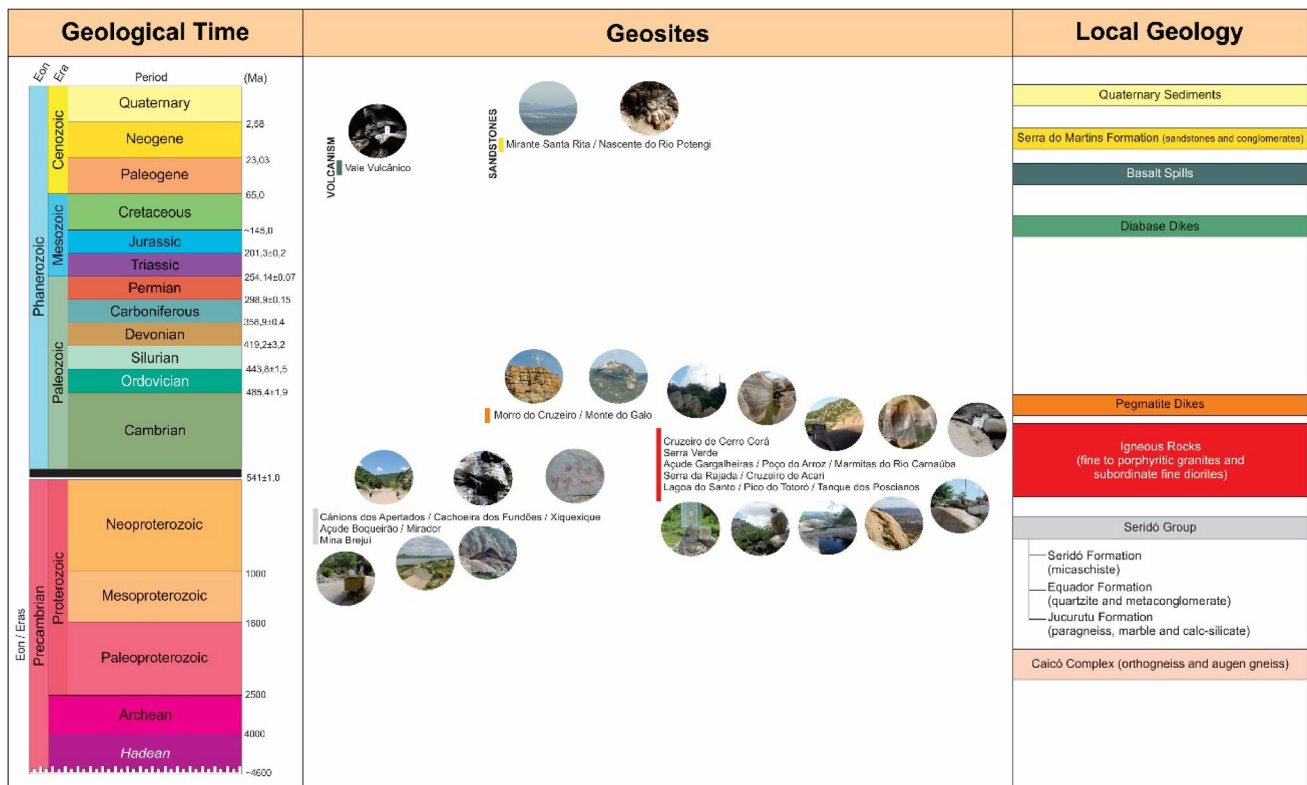


Fig. 4 Simplified stratigraphic chart with Seridó Aspiring Geopark’s geosites

to keep cattle in periods of drought. Upon arriving at Seridó, the colonizers came across the Tapuias Indians — *Tarairirus* — who inhabited the Acauan stream at the foot of the granite inselberg of the same name, and who used lithic artifacts produced with polished stones (granitic rocks, gneisses, and even basalt) and cutting stones (flint, quartz crystals, among others) and also descended from the first inhabitants of the regions who made several rock inscriptions in various rock shelters (granite, sandstone) throughout the region.

After the cattle cycle and the extinction of the indigenous people on the Acauan stream, there was the cotton cycle, planted in soils between rocks, which made mechanization difficult, thus requiring a large amount of labor for planting and collecting. This was the period when the great cotton farms emerged, known as the Seridó's white gold (Dantas and Morais 2001).

With the decline of the cotton cycle, the next cycle would come, that of mining, which started around the second world war with the discovery of scheelite near Ribeira da Acauan on the Barra Verde property in the municipality of Currais Novos and which gave rise to one of the largest mines of scheelite in the world. Thanks to the scheelite mining and its demand for the manufacture of weapons during the second world war, it was possible to exchange with geologists from all over the world who came to know and therefore walk and study the geology of Seridó, thus discovering several other mineral occurrences throughout the Region.

Together with agriculture, mining was an important economic activity in fostering the development of Seridó, artisanal mining in the nineteenth century, as well as mining on an industrial scale in the mid-twentieth century, exploiting the resources of scheelite, tantalite, columbite, gems, and ornamental rocks (Carvalho 2005). The large amount of occurrences and mineral deposits in the region shows the richness of the geodiversity of the Seridó Geopark, as discussed by Silva et al. (2019b). Therefore, mining activity, with its expansion following the development of the region, is increasingly approaching in urban centers and geosites, which can become a threat to their surroundings, just as urban space presents itself as a threat to geodiversity (Silva et al. 2019a).

Data from Costa et al. (2019) show, for example, that the urban limits of Currais Novos, Acari, Parelhas, and Carnaúba dos Dantas municipalities are less than 1 km from areas authorized for mining. The same work shows that thirteen of the twenty-one geosites of the geopark are less than 2 km from areas in activity of mineral extraction, with four directly involved with mineral extraction activities in the surroundings of their areas: Mina Brejuí, Açude Boqueirão, Cânions dos Apertados, and Açude Gargalheiras.

Likewise, mining can be a threat to the conservation of geoheritage; the proximity of urban groups added to the lack of education impacts the integrity of elements of

geodiversity present in geosites, despite the fact that most of the properties where these geosites are inserted are of a private nature. Silva et al. (2019a) record the damages observed in geosites, such as graffiti, waste and garbage disposal, excessive use, sample removal, and religious inscriptions. The proximity of geosites with the urban limit, given by the disorderly growth towards the neighborhoods of areas susceptible to the short natural dynamics, in turn can provide some geological and geotechnical risks. It was verified in the twenty-one geosites the distance in relation to the areas with the highest concentration of population, the urban limits of the geopark municipalities; these distance relationships, in addition to the geosites and respective municipalities, are summarized in Table 1.

Four of the geosites — Cruzeiro de Cerro Corá, Cruzeiro de Acari, Monte do Galo and Morro do Cruzeiro — are inserted within the limit of urban density of the municipalities. It is interesting that all of these geosites are associated in some way with the Christian religious heritage, one of the several marks of the immaterial cultural identity of the people of Seridó. Precisely at these sites, Silva et al. (2019a) highlighted the majority of the deteriorations studied for the entire territory, resulting from anthropic action, as well as due to natural phenomena. In these places, the main associated natural hazards are in the presence of boulders, rounded blocks products of spheroidal exfoliation, and their risk of falling blocks in houses and buildings nearby (Dorren 2003), mainly in catastrophic events of rains and occasional earthquakes, enhanced due to the absence of vegetation on the slopes and spaces between geosite and buildings (Alejano et al 2010). Figure 5a shows the potential risks seen in this context involving falling blocks.

Still the Cruzeiro de Acari, in the municipality of Acari, in its surroundings, the city network approached the banks of the Acauã river, with houses less than 30 m from the river course and absence of riparian vegetation, which means risk of flooding in exceptional floods. In the vicinity of Morro do Cruzeiro, the residences are also in a small limit of marginal space in relation to this watercourse, built on its plain inundation (Fig. 5b).

Vegetation plays a fundamental role in reducing these risks, both for the fall of blocks and to mitigate floods, the use of caatinga wood for the production of red ceramics and the burning of it to occupy the space is one of the driving conditions for the increase in geological risks. In Fig. 5c, it is possible to visualize the environmental problem generated around the geosites, in this case in the Cruzeiro de Cerro Corá geosite.

Another five geosites are in the immediate vicinity of the urban limits, distant from 1 to 3 km from them: Açude Boqueirão, Mirador, Poço do Arroz, Mirante Santa Rita, and Xiquexique. Also in the vicinity, with 3 to 5 km, are the geosites Açude Gargalheiras, Nascente do Rio Potengi,

Table 1 Seridó Geopark geosites' to urban areas distance

	Geosite	Municipality	Distance (km)
Into urban area	Cruzeiro de Cerro Corá	Cerro Corá	-
	Cruzeiro de Acari	Acari	-
	Monte do Galo	Carnaúba dos Dantas	-
	Morro do Cruzeiro	Currais Novos	-
1–3 km to urban rea	Açude Boqueirão	Parelhas	1.38
	Mirador	Parelhas	2.05
	Poço do Arroz	Acari	2.07
	Mirante Santa Rita	Lagoa Nova	2.08
3–5 km to urban área	Xiquexique	Carnaúba dos Dantas	2.37
	Açude Gargalheiras	Acari	3.49
	Nascente do Rio Potengi	Cerro Corá	3.57
	Mina Brejuí	Currais Novos	4.21
5–7 km to urban área	Cachoeira dos Fundões	Carnaúba dos Dantas	4.50
	Serra da Rajada	Acari and Carnaúba dos Dantas	5.26
	Vale Vulcânico	Cerro Corá	5.33
	Pico do Totoró	Currais Novos	5.33
> 7 km to urban área	Cânions dos Apertados	Currais Novos	6.19
	Tanque dos Poscianos	Lagoa Nova	8.09
	Marmitas do Rio Carnaúba	Acari	8.09
	Lagoa do Santo	Currais Novo	8.37
	Serra Verde	Cerro Corá	9.84

Mina Brejuí, and Cachoeira dos Fundões. Despite not being in urban limits, many of these geosites have villages in their surroundings.

The geosites Mirante Santa Rita and Nascente do Rio Potengi have, in the surroundings, houses close to the escarpments of the plateaus and cuestras of the Serra de Santana, while the geosites Açude Boqueirão and Mirador have a community close to slopes with blocks and quartzite plates, as well as the mining town of Mina Brejuí Geosite and some houses close to the Açude Gargalheiras Geosite, but with other lithologies composing its relief, schist, and granite respectively. In addition, the occupation of spaces on the banks of the reservoirs of the Açude Boqueirão and Açude Gargalheiras geosites is a risk of flooding.

Of the geosites that are 5 to 7 km apart, only Serra da Rajada with little risk of falling blocks and abundant vegetation on the slopes (Fig. 5d) and Pico do Totoró with houses close to the reservoir suffer some possibility of geological impact. The four geosites that are more than 7 km from the urban area do not present situations that express anthropic risks.

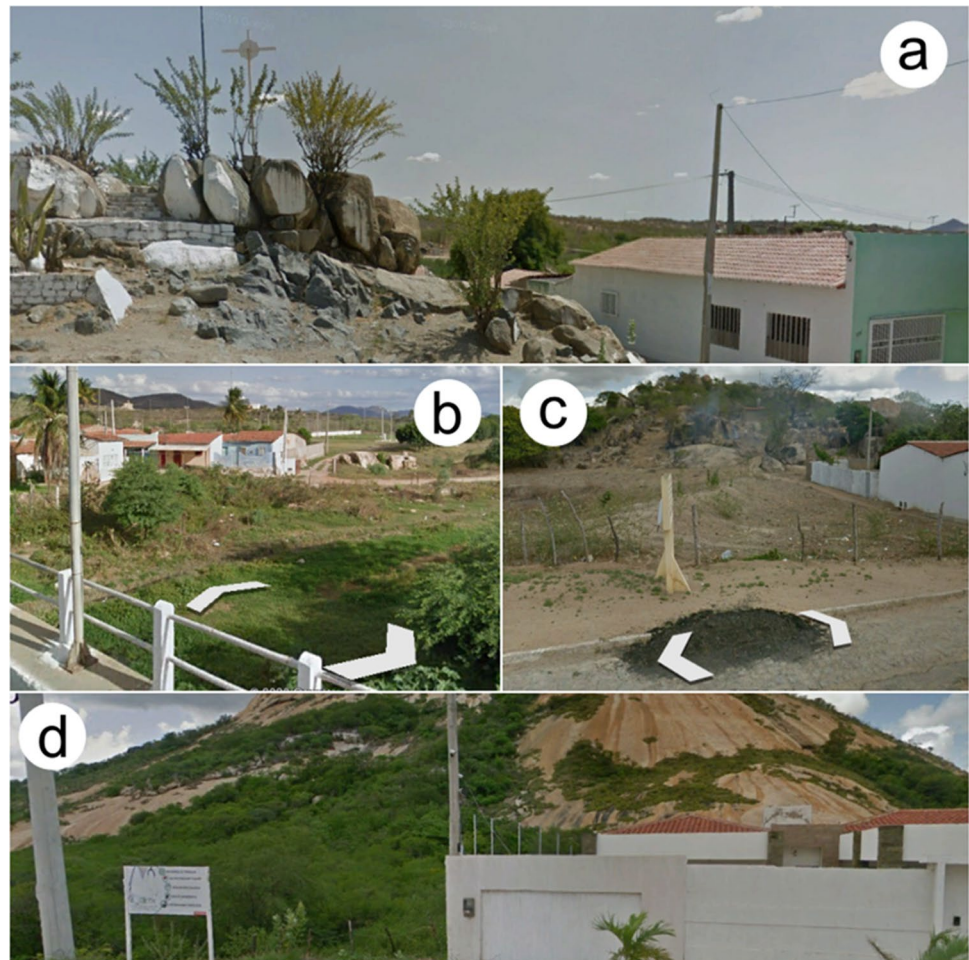
In addition to the position of geological and environmental risks associated with buildings, there are also the weaknesses of living in the region that is so vulnerable to climate change, so the geopark can be a monitoring and transformation agent for the territory's community, thus joining the strategies presented by Correia et al. (2020).

In summary, the natural risks to communities close to the Seridó Aspiring Geopark geosites can be grouped into four types of vulnerability: (i) fall and displacement of granitic boulders; (ii) displacement and falling blocks of metamorphic rocks such as shales, quartzites, paragneisses, and metaconglomerates; (iii) landslide in sedimentary escarpments of Serra de Santana; and (iv) flooding in the floodplains of rivers, lagoons, and dams. Figure 6 shows the risk classifications associated with geosites together with the municipal urban boundaries in the geopark territory. It is observed that the risks are maximized in places of high declivity and in proximity to the urban network.

Geoconservation, Environment, and Society in Seridó Aspiring Geopark

The Seridó Aspiring Geopark, with its rich geoheritage and diversity of abiotic processes combined with its importance for its people's history and culture, is not exempt from the threats of deteriorating access to knowledge and the scenic beauty of Seridó. Undoubtedly, the geopark proposal, its actions, and its legitimacy to integrate the UGG/GGN are important strategies for geoconservation, but the conservation of geological heritage requires the mobilization of different sectors, such as education, public policies, management, and law. In the Brazilian scenario, widespread ignorance about the theme explains the gaps in the

Fig. 5 Potential geological and natural hazards to constructions close to geosites observed in StreetView © tool: **a** granitic boulders Cruzeiro de Acari geosite next to houses; **b** village in Morro do Cruzeiro geosite imediations fixed on São Bento river floodplan, the Morro do Cruzeiro geosite are at photo background; **c** buildings in granitic slope of Cruzeiro de Cerro Corá geosite, during the scene capture was registered caatinga vegetation burning to agriculture and land occupation; **d** vegetation protecting the houses in granitic slope of Serra da Rajada geosite. Source: Google Street View



instruments for direct protection of this heritage (Piranha et al 2011).

Among all geosites, only Morro do Cruzeiro has direct protection via legal mechanism (Currais Novos 2015), which determines the inclusion of the natural geological attractions, within a radius of 100 m, as a historical, natural, and artistic landmark. In fact, some municipal legal mechanisms also suggest the protection of geoheritage (Cerro Corá 1990; Currais Novos 1990; Lagoa Nova 1990; Parelhas 1990; Carnaúba dos Dantas 2016; Acari 2017) and establish the protection of relevant and notable natural landscapes or natural environmental heritage, protecting the elements of geodiversity as monuments. From these municipal organic laws, that of Carnaúba dos Dantas protects the Serra da Rajada, Monte do Galo geosites, and other monuments of an abiotic nature important for its people; in Currais Novos the geosites Pico do Totoró, Lagoa do Santo and the slopes of Serra de Santana have special protection under the legislation; likewise, Cerro Corá specifies the Cruzeiro de Cerro Corá and Serra Verde geosites, as well as the slopes of Serra de Santana and other important geodiversity sites for special regimes.

It is worth mentioning that another legal mechanism for the direct protection of geodiversity is the protection of speleological heritage (Brasil 1988, 2008a, 2009). In the case of the Seridó Aspiring Geopark, in which none of the territory's geosites has the speleological heritage as a highlight, the cavities become an indirect measure to protect the geoheritage, when associated.

The geopark territory has a total of thirteen cavities registered with the CECAV, seven of which are located in the municipality of Carnaúba dos Dantas, five caverns, two shelters, and one of the cavern is just 500 m from the Cachoeira dos Fundões Geosite. Another three caves and a shelter are located in Cerro Corá; two of the caves sculpted in granite boulders, forming shelters in tafoni, are part of the Serra Verde Geosite area. Two other cavities registered are in the municipalities of Acari and Parelhas, in Acari, three other caves were mapped by Medeiros (2003) but were not properly registered in the CECAV database: Loca do Pau Seco, Gruta do Abreu, and Caverna do Saturno. Just as a shelter in the Cânions dos Apertados Geosite was registered by Silva (2018).



Fig. 6 Map of geological and urban hazards related to Seridó Aspiring Geopark geosites

Except for some of the municipal organic laws of the six municipalities that make up the territory, the mechanisms that can protect and guarantee the sustainable use of geoheritage are indirect via protection of other defined heritage, be they historical-archeological, ethnic-social, cultural, and biodiversity. Pereira et al. (2008) state that some legal instruments such as Brasil (1937, 2000) may cover geoheritage. Since the first legislation covers archeological sites and archeological heritage that may be closely related to geodiversity (Nascimento and Santos 2013), the same can be true for biodiversity heritage protected by the National System of Nature Conservation Units (SNUC).

In the case of archeological sites in the territory, there are a total of eighty-five inserted in the CNSA-IPHAN database, three in Acari, sixty-three in Carnaúba dos Dantas,

seven in Cerro Corá, five in Currais Novos, two in Lagoa Nova, and five in Parelhas. Two geosites are distinguished by the number of archeological sites that together with the geoheritage compose its landscape, Xiquexique with fifteen and Cachoeira dos Fundões with nine. The Lagoa do Santo, Poço do Arroz, and Serra da Rajada geosites each have an archeological site registered with the CNSA-IPHAN. While four geosites are at least 1 km from an archeological record: Mirante Santa Rita, Nascente do Rio Potengi, Pico do Totoró, and Monte do Galo. And finally, four geosites also have archeological heritage, but they are not properly regulated, such as Serra Verde, Tanque dos Poscianos, Marmitas do Rio Carnaúba, and Mirador.

The Xiquexique and Cachoeira dos Fundões geosites stand out not only for the number of archeological sites

but also for the exuberance of the rock paintings from the Nordeste Tradition and Seridó Subtradition, besides rock engravings, filled or not, associated with the Itaquiara traditions, in addition to lithic materials such as flint and quartz, coal fragments, and traces of pigments (Luna and Nascimento 1998; Ferreira 2013). Table 2 summarizes the geosites and their associated archeological sites, it is noteworthy that some archeological sites, as in the case of Mirador or Xiquexique, are registered in CNSA-IPHAN as descriptive files, but do not integrate the vector file system of georeferencing, in this situation, there are at least eleven more archeological sites, totaling ninety-six archeological heritage sites in the geopark's territory.

Following the heritage conservation strategies and their applications as indirect mechanisms of geoconservation, there are two conservation units established by SNUC in the territory of the Seridó Aspiring Geopark. Being one of the state-level responsibility, the Florêncio Luciano State Park (Rio Grande do Norte 1988) with an area of 6.67 km², located in the municipality of Parelhas, close to the Açude Boqueirão and Mirador geosites, but which is not effectively managed according to Teixeira and Venticinque (2014) and, therefore, does not fulfill its role of conserving the caatinga and geomorphological units in its surroundings. The other conservation unit is a federal and private responsibility, located in the municipality of Acari, with an area of 1.52 km² and was established by Brasil (1996), with the objective of ordering the use and protection of the caatinga ecosystem, this unit called Ser Nativo Private Reserve of the Natural Heritage (Ser Nativo RPPN) is about 1.5 km east of

the Açude Gargalheiras Geosite and safeguard biome and features similar to that found in the geosite.

In addition to these areas in the different spheres of Brazilian public power, SNUC recognizes the international model created by UNESCO, the Biosphere Reserves. At the Seridó Aspiring Geopark, an area of 73.59 km² is part of the Caatinga Biosphere Reserve created in 2001, covering an area of 198,000 km², in the Northeast Brazil states and in north of Minas Gerais state, Southeast region of Brazil. This area of the Caatinga Biosphere Reserve is located in the municipality of Parelhas and fills about 14.33% of the total area of the municipal territory and 2.62% of the geoparque area. However, the areas that are comprised in the geopark are buffer zones and transition zones; these constitute limits where the process of using resources is built on sustainable bases, also allowing activities that do not result in damage to core areas.

The Brazilian Forest Code (Brasil 2012a) also establishes that vegetation up to 30 m from water courses must be preserved, thus following the application of this legal mechanism, geosites such as Nascente do Rio Potengi, Vale Vulcânico, Lagoa do Santo, Pico do Totoró, Cânions dos Apertados, Açude Gargalheiras, Poço do Arroz, Marmittas do Rio Carnaúba, Cachoeira dos Fundões, and Açude Boqueirão may have their geodiversity and geoheritage's elements conserved, since they are associated with rivers, streams, and ponds that make up the region's hydrography.

Regarding areas of environmental reserves not included in the SNUC, only the municipal legislation of Carnaúba dos Dantas mentions the Horto Florestal Municipal de Carnaúba

Table 2 Archaeological sites of CNSA-IPHAN and their association with Seridó Geopark geosites

Geosite	Quantity	Archaeological sites
<i>Serra Verde</i>	1	Site not registered
<i>Tanque dos Poscianos</i>	1	Site not registered
<i>Mirante Santa Rita</i>	1	Close to Santana X
<i>Nascente do Rio Potengi</i>	2	Close to Santana I and II
<i>Lagoa do Santo</i>	1	Pedra do Letreiro site
<i>Pico do Totoró</i>	1	Pedra Furada
<i>Poço do Arroz</i>	1	Poço do Artur site
<i>Marmittas do Rio Carnaúba</i>	1	Site not registered
<i>Serra da Rajada</i>	1	Escondido da Rajada
<i>Monte do Galo</i>	2	Close to Cachoeira dos Tanquinhos I and II
<i>Xiquexique</i>	15	Xiquexique 1a and 1b, Xiquexique 2a and 2b, Xiquexique 3, Xiquexique 4, Xiquexique 6, Furna do Pau Darco, Talhado do Menalças, Talhado das Pirogas, Sítio do Marimbondo, Abrigo do Morcego, Sítio Mão Redonda I and II, Serrote do Zé do Bode
<i>Cachoeira dos Fundões</i>	9	Fundões I and III, Pedra da Mesa, Pedra do Cavalo, Pinhão Branco, Pedra de Macambira, Poço do Caramuru, Furna da Desilusão e Furna do João
<i>Mirador</i>	1	Site not registered

dos Dantas, a type of caatinga reserve and non-native algarobas forests under the responsibility of the Brazilian Institute of Environment and Renewable Natural Resources (IBAMA) and municipal bodies. Despite being in the vicinity of this ecological area, the Monte do Galo Geosite does not benefit from the limits of the garden. As a measure to strengthen SNUC’s policies, it was proposed to evaluate the degrees of priority of Brazilian biomes for the conservation of their biological diversity. The data had their parameters defined in Brasil (2003), basically consisting of the biological richness of ecosystems, importance for traditional communities, and vulnerability status.

The classes recognized as being a priority for conservation, sustainable use, and sharing of benefits for biodiversity

were defined by Brasil (2018), being selected according to their biological importance, with the classes “extremely high,” “very high,” “high,” and “insufficiently known,” as well as classifying its needs for action priority as “extremely high,” “very high,” and “high.”

In the Seridó Aspiring Geopark, four areas were classified as being of high biological importance and of very high priority for decision making in order to promote conservation, these areas total 996.65 km², that is, a coverage of 35,56% of the geopark area, and encompassing in its limits ten of the twenty one geosites of the geopark territory: Cruzeiro de Cerro Corá, Nascente do Rio Potengi, Lagoa do Santo, Pico do Totoró, Mina Brejuí, Açude Gargalheiras, Poço do Arroz, Cruzeiro de Acari,

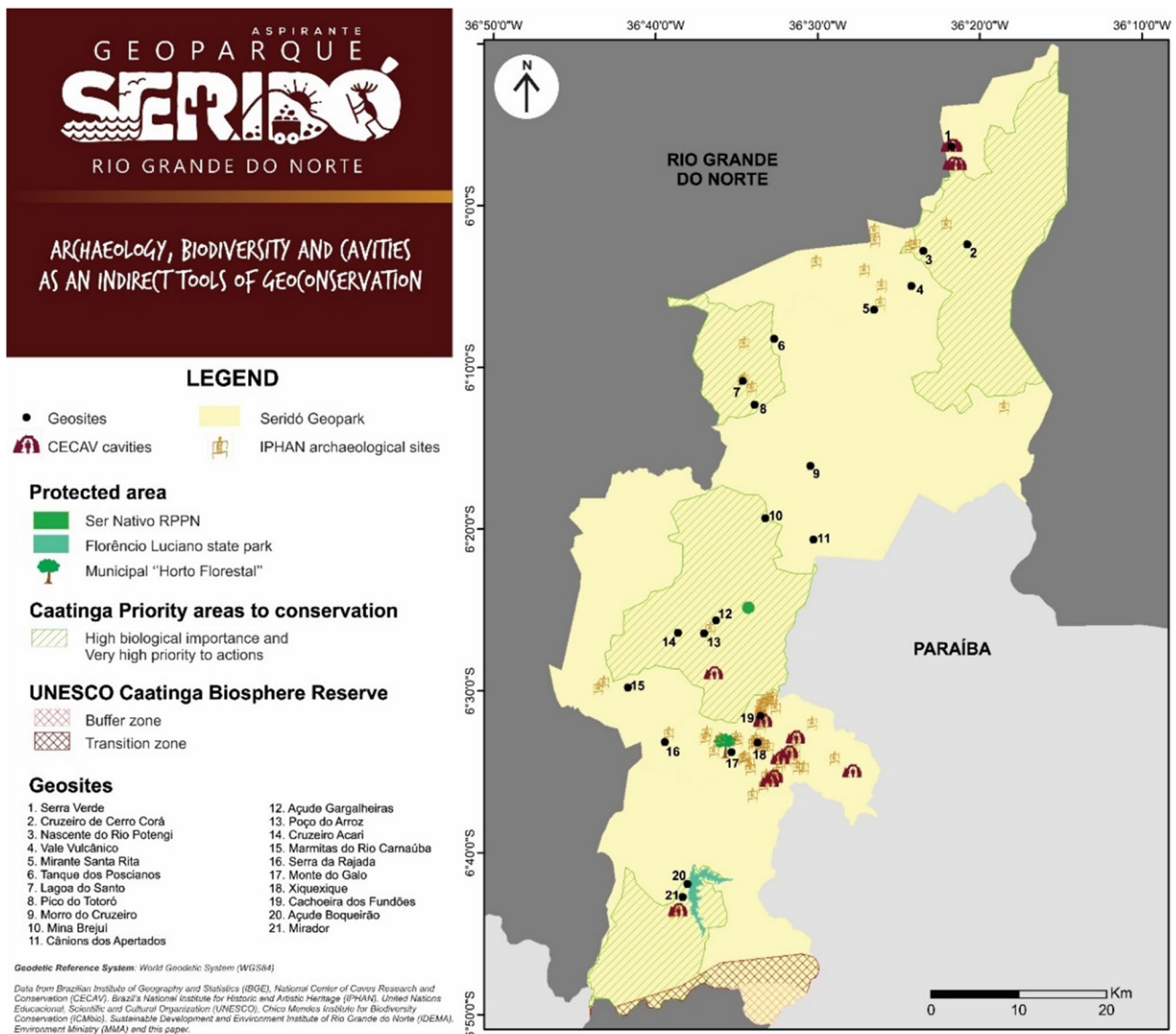


Fig. 7 Map of archeological sites, Caatinga biome conservation and cavities as geoconservation indirect elements in Seridó Aspiring Geopark

Açude Boqueirão, and Mirador. Figure 7 shows the situation of the cavities registered in the CECAV in the geopark territory, as well as the conservation units, the priority areas of conservation of the caatinga and relations with the geosites; the archeological sites of CNSA-IPHAN are also represented.

Another important strategic resource in order to promote geoconservation is the social dimension, in legal terms and in affirmative policies, even though indirectly, it can limit the degradation and consumption of abiotic resources, as well as stimulate the practice of sustainable development. In this dimension, indigenous lands, quilombola communities, and settlements are expected to constitute areas with restricted exploration and sustainable

community use in these territories. Although Seridó has several records of indigenous culture — tapuia, janduí, paiacu, jenipapo-açu, icó peoples — there are no self-declared indigenous groups, nor demarcated lands (Cavignac and Alveal 2020).

However, in relation to traditional African and Afro-Brazilian groups, Seridó Aspiring Geopark has in its territory a wealth of intangible cultural heritage and heritage in quilombola communities. This historical reframing in territorial guarantee and occupations of their lands is defined in Article 68 of the Transitional Constitutional Provisions Act in the Federal Constitution (Brasil 1988) and Decree 4887 of 20 November 2003 (Brasil 2003). In the geopark, there are five traditional quilombola communities: Negros do Boinho in



Fig. 8 Map of social and afrocultural heritage as geoconservation indirect elements in Seridó Aspiring Geopark

Cerro Corá, Macambira in Lagoa Nova, Negros do Riacho Angicos in Currais Novos, Sítio Barra-Filhos de Higinos-Negros do Saco in Acari and, in Parelhas, Boa Vista dos Negros community. Of these communities, only Negros do Boinho is not certified and only two have specific legislation to define quilombola territory: Boa Vista dos Negros (Brasil 2012b) and Macambira (Brasil 2016). In these areas demarcated with specific legislation and registration in the INCRA georeferencing system, there is no presence of geosites. There are also other quilombola communities not registered in the PCP, such as Negros do Totoró, near Pico do Totoró Geosite in Currais Novos, which has been losing space and memories for the expansion of possessions and agriculture (Cavignac et al. 2020a, b).

Finally, one more social resource can be used for indirect conservation of the geopark's geoheritage: rural settlements. These units of sustainable family agriculture and land democratization of INCRA are regulated by the Land Statute (Brasil 1964) and Execution Standard DT/INCRA 69 (Brasil 2008b). In the territory, there are nine settlements, two being installed, six being structured, and one being consolidated, all are located near Serra de Santana and contain five geosites in its vicinity. Figure 8 maps the demarcated areas for settled quilombola and rural communities within the geopark territory.

Conclusions

The Seridó Aspiring Geopark, currently a candidate for the title of UNESCO Global Geopark, has a remarkable geological heritage, represented by 21 geosites that, in addition to having scientific value, are integrated into the local landscapes and cultures, with associated educational and tourist values.

In relation to geological hazards, it is observed that these are due to urban planning and directing its network towards geodiversity elements, because they are sources of resources such as water and because they also have intrinsic and immaterial heritage value connected with the population, as exemplified by the numerous religious landmarks in mountain ranges, pegmatitic dikes, or granite slabs.

Undoubtedly one of the municipalities most contemplated with indirect mechanisms for geoconservation is Carnaúba dos Dantas for its richness in archeological sites, cavities, biodiversity, as well as Lagoa Nova stands out in the social dimension with demarcated areas of quilombolas. Acari and Cerro Corá have mechanisms due to the biodiversity with priority for conservation. On the other hand, Currais Novos is the municipality that is least contemplated, in territorial coverage, with laws for natural

heritage, a fact interestingly compensated by its municipal legislation providing direct protection.

The magnificent biological, historical, cultural, and social diversity of the territory of the Seridó Aspiring Geopark can be important allies in the conservation of the geological heritage, knowing that in the scenarios of the public spheres, there are still weaknesses in the specific legislation for the abiotic environment. In addition, the use of social areas in favor of sustainable development can be essential for the success of the geopark's purposes, so education actions in quilombola communities and settlements expand the democratization frontiers of development and knowledge about the local heritage.

Declarations

Conflict of Interest The authors declare no competing interests.

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